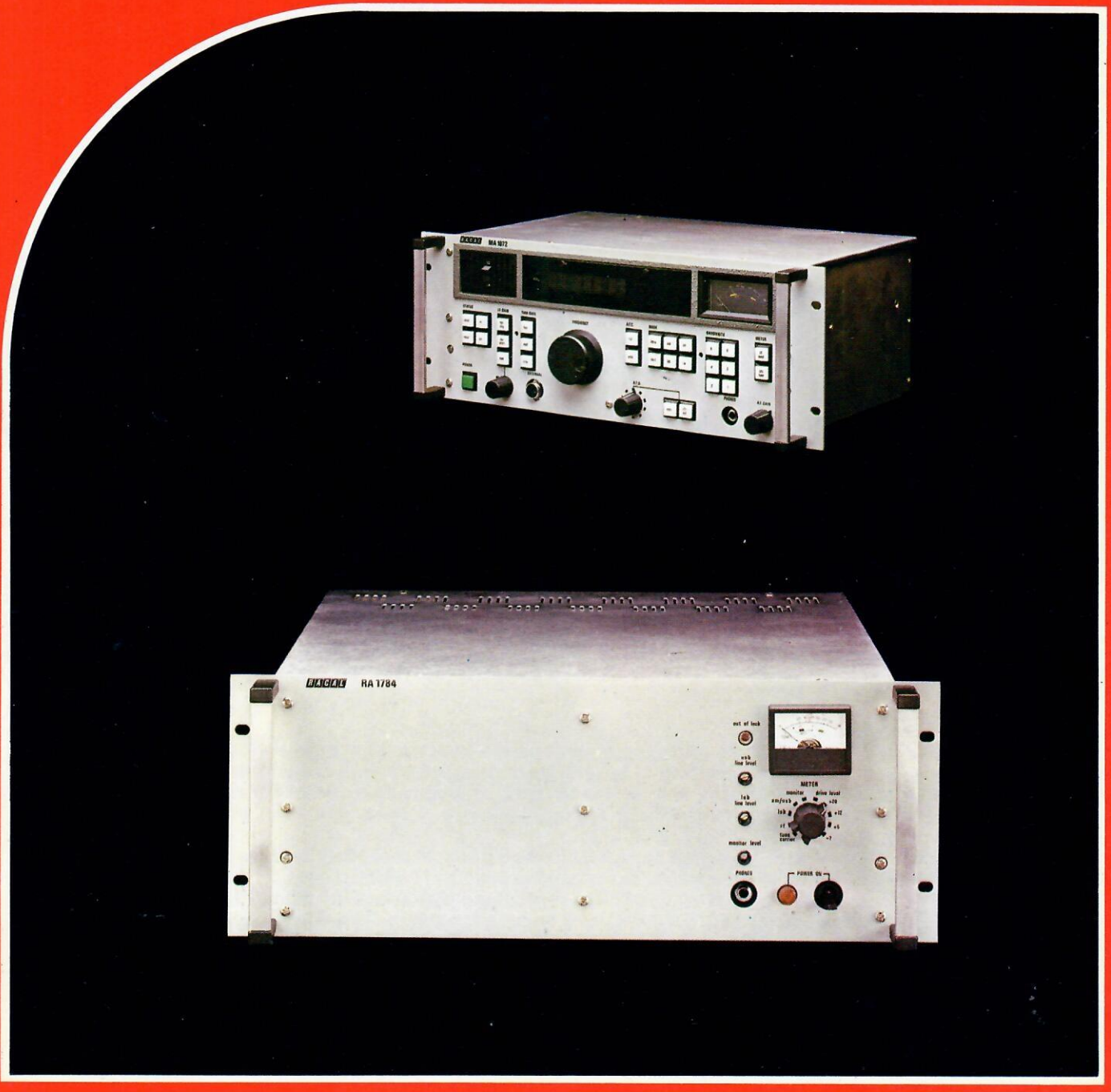
RA1784

Synthesized remote control communications receiver

Frequency range 15 kHz to 30 MHz in 10 Hz increments
Full serial-data remote control
Suitable for computer controlled systems
Intermodulation products better than −90dB
Unsurpassed signal path performance
Built-in options for ISB and AFC
High MTBF–Low MTTR
Nato Stock Numbers: RA 1784 5820-99-643-4471
MA 1072 5820-99-643-4473

Racal Communications Limited



Publication No. 7003-1

Synthesized remote control communications receiver type RA 1784

The Racal RA 1784 receiver combines the unrivalled signal handling and 'continuously-tunable synthesizer' characteristics of the well-proven RA 1770-Series with the most up-to-date data-handling techniques in an equipment of exceptional performance and versatility, all functions of which may be controlled from an extended or remote operating position. Covering the frequency range 15 kHz to 30 MHz and suitable for all modes of reception, the receiver will find wide application –particularly in monitoring and surveillance roles. It has already been adopted as a standard equipment by the U.K. Government and is in use in many other countries throughout the world. These equipments are also in service with Nato, stock numbers 5820-99-643-4471 (RA 1784) and 5820-99-643-4473 (MA 1072) having been allocated.

The RA 1784 may be manually-controlled by use of the MA 1072 Remote Control Unit, or interfaced with a computer for surveillance or other repetitive or special-purpose applications. Control is exercised by a serial-data system known as SCORE (Serial Control Of Racal Equipment) either on an extended or fully remote basis. The MA 1072 incorporates the unique system of single-knob frequency control permitting the receiver to be continuously tuned across the full 30 MHz band in 10 Hz increments with the smooth feel and flexibility of a conventional VFO, yet with the superb accuracy and stability of the internal or external frequency standard.

Three rates of tuning are provided, giving the operator the choice of fast tune for rapid search or frequency changing, and fine control for precise setting. The tuned frequency is indicated to within 10 Hz on a seven-digit non-flicker LED display which is easily read under all lighting conditions without operator strain.

The RA 1784 has facilities for the reception of SSB)upper or lower sideband), AM and CW, while optional modules may be fitted for ISB and AFC operation. The receiver will also handle FSK with an external adaptor.

The advanced engineering techniques embodied in the receiver design, its rugged construction, and the high standards of components, materials, workmanship and quality control employed in its manufacture ensure the highest levels of performance and reliability under arduous environmental conditions in all parts of the world.

Control System

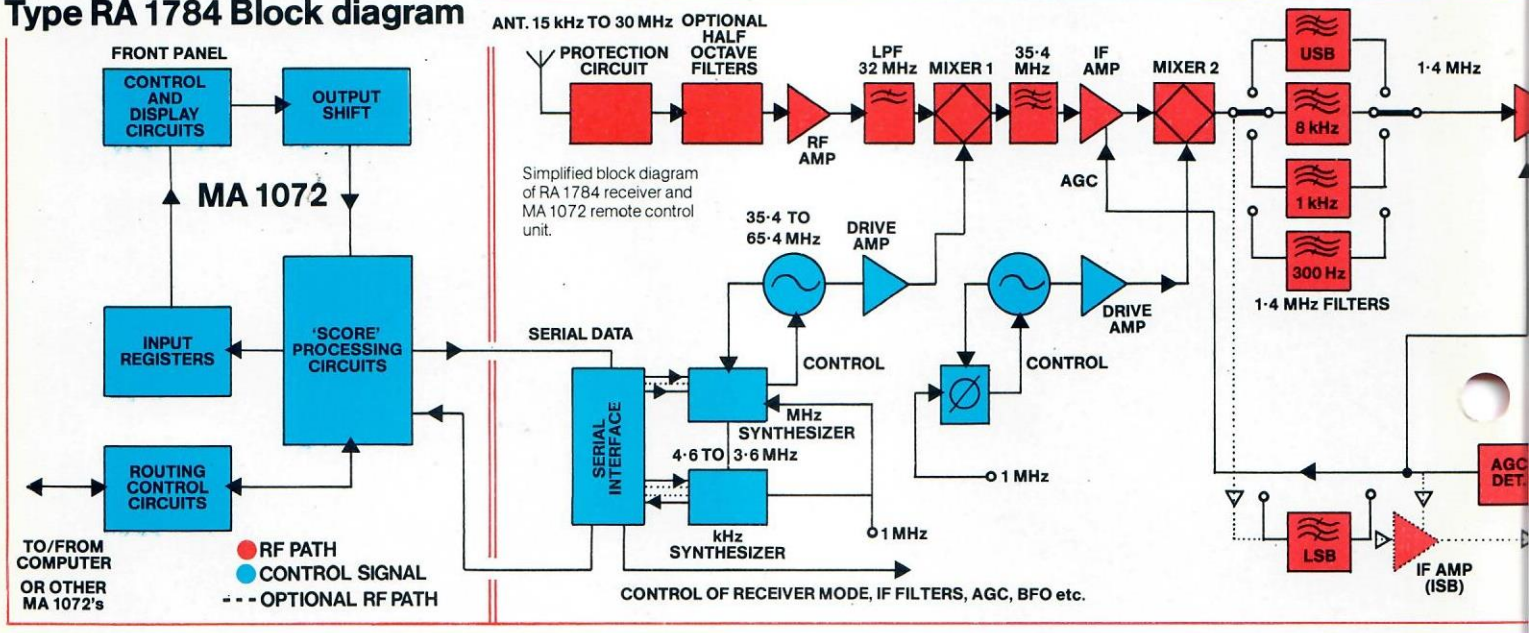
The SCORE system permits control of all the variable facilities of the receiver, including not only tuned frequency, mode and bandwidth selection, etc., but also analogue functions such as IF gain and BFO frequency, to be available at an operating position removed at some distance from the receiver. This may be on an extended basis (up to 100 metres) or fully remote (over virtually unlimited distances), control in both cases being exercised by means of the MA 1072 Remote Control Unit.

SCORE is a time-sharing data-multiplexing system in which the parallel control information is converted into serial form for transmission over simple wire links. In the extended control case, only three cable pairs are required: one for forward control, one for revertive check data, and one for a synchronizing clock waveform. For full remote control over greater distances, standard data modems are used on a normal unconditioned four-wire telephone circuit.

The system operates by scanning each of the parallel control wires in the MA 1072 in sequence and assembling the data gathered into a composite serial 48-bit data 'frame' in which each parameter being controlled is allocated a number of bits. This data 'frame' is then transmitted over the forward control cable. In the receiver, this serial information is converted back into parallel form in the Serial Interface Unit and the appropriate control function performed.

In the reverse direction, revertive check data, such as frequency,

Type RA 1784 Block diagram



Simplified block diagram of RA 1784 receiver and MA 1072 remote control unit.

Principle of Operation *The Signal Path*

The input signal is fed from the antenna via a protection circuit (and optional half-octave filters, where fitted) to a linear RF stage. After amplification, it passes via a 32 MHz low-pass filter to Mixer 1 where it is combined with a variable-frequency output from the synthesizer. The frequency of this output, in the range 35.4 to 65.4 MHz, is selected by the controller and is determined by the tuned frequency of the receiver. The synthesizer is tuned in minimum increments of 10 Hz ('slow tune'), with alternative rates switchable to provide medium or fast tune.

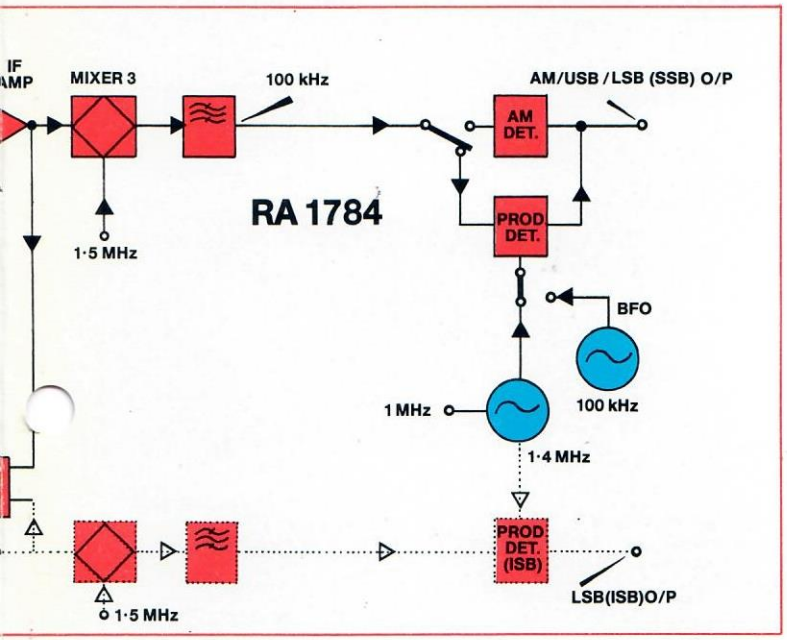
The 35.4 MHz (first IF) output from Mixer 1, is fed via a bandpass filter and IF amplifier to Mixer 2, where it is combined with a fixed 34 MHz output derived from the frequency standard to produce a second IF of 1.4 MHz. Dependent upon the mode and bandwidth selected, this 1.4 MHz signal is then fed to the sideband or symmetrical IF selectivity filters. The output from the selected filter is passed to the main IF amplifier and then to Mixer 3, where it is combined with a fixed 1.5 MHz output derived from the frequency standard to produce a final IF of 100 kHz. The gain of the various IF amplifier stages is controlled by an AGC amplifier and detector.

The 100 kHz final IF is fed to a product detector for CW/SSB/ISB modes, and an envelope detector for AM. For CW, a variable BFO covers the range ±4 kHz about the 100 kHz IF, while on SSB or ISB reception a 100 kHz output derived from the frequency standard provides a reinserted carrier. In the ISB mode, a second identical IF amplifier, 3rd mixer, a product detector and AF amplifier chain provide the lower sideband output.

mode and bandwidth settings, RF signal strength and fault indication, are transmitted back to the Remote Control Unit using the same method. Operation of the whole control system is synchronized by the clock signal, which also determines the data rate – between 100 and 20,000 bauds.
Examples of typical control systems are shown in the accompanying block diagrams.

General Description RA1784 Receiver

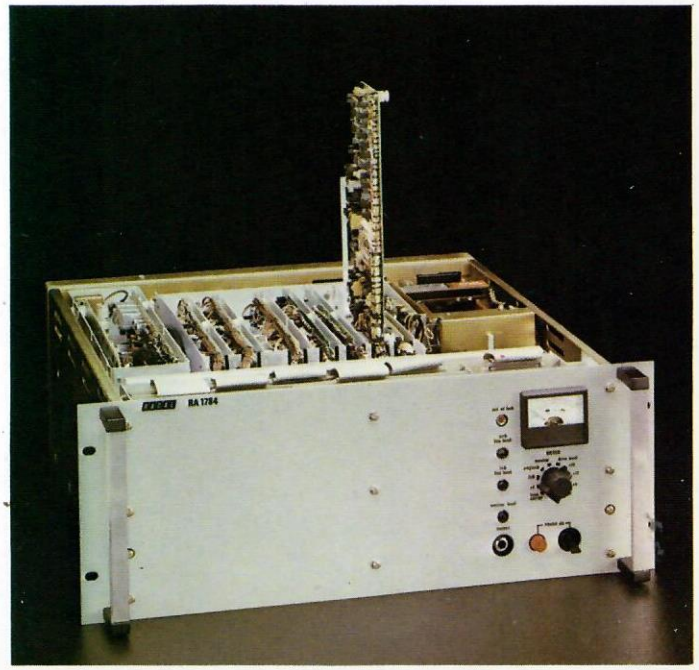
The design of the RA 1784 embodies the latest techniques in mixer and signal path development to produce a performance with respect to dynamic range, intermodulation products, reciprocal mixing, cross modulation, blocking and spurious responses far exceeding that found in any other receiver of its type currently available. The receiver will accommodate a total of six filters. Two may be asymmetrical SSB/ISB with either 3 kHz or 6 kHz nominal bandwidths, leaving space for fitting symmetrical IF selectivity filters or AFC carrier filter, according to user requirements. Additional positions for symmetrical IF selectivity filters become available if SSB/ISB filters are not fitted.
For CW operation a fully synthesized BFO is fitted which has a range of ±4 kHz in 10 Hz increments giving the smooth feel of a conventional slow-motion drive. Any fixed offset frequency within the range may be internally preset in the MA 1072.
In addition to the normal modes of reception provided in the basic receiver, optional units may be fitted within the main receiver frame to permit reception of ISB as well as AFC operation. The standard version is fitted with a wideband RF amplifier unit but a half-octave filter unit may be incorporated as an option when additional pre-selection is necessary.
The high stability of the RA 1784 is achieved by the frequency synthesizer which is referenced to a built-in frequency standard. Alternative standards are available as options and



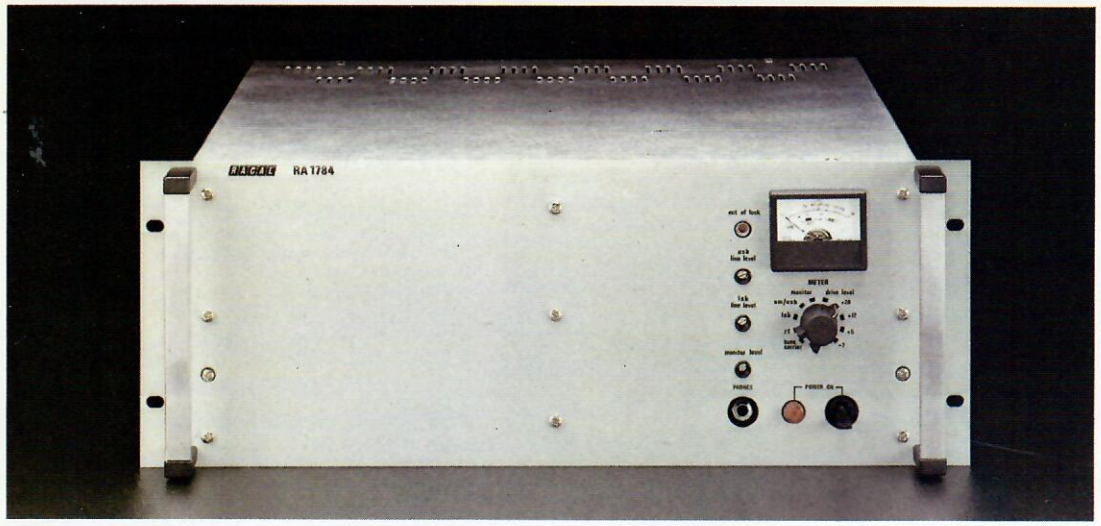
the receiver may be operated from an external frequency source when required.
The mechanical construction provides a very robust receiver capable of operating under extreme environmental conditions of vibration, shock, temperature and humidity. The layout permits maximum accessibility for servicing, all components being accessible without the use of extension leads or adaptors.
The flexibility of the receiver is further enhanced by the provision of comprehensive input and output connectors on the rear of the chassis permitting the use of the receiver as the basis of more sophisticated systems. For speech diversity operation, modules MM 532/1 and /2 are available as options.
A headphone jack is provided at the receiver while a monitor speaker and headphone jack are fitted in the Control Unit MA 1072.
The RA 1784 is compact and is normally supplied in rack mounting form with a separate control unit MA 1072. Alternatively, the equipment may be supplied in bench mounting cabinets.

MA 1072 Remote Control Unit

The MA 1072 Remote Control Unit is designed for use with the RA 1784 in both extended and remote control configurations. Primarily intended for rack or console mounting, the MA 1072 carries all the controls and displays normally associated with the receiver. Single knob electronic tuning of the receiver is achieved through a digitizer whose output is processed and serialized for transmission within the SCORE data frame to control the synthesizer. The front panel also carries rotary controls for BFO setting, AF gain and IF gain.
Push-button switches are used to select the principal receiver functions including operating mode, filter bandwidth, tuning rate, AGC time constant and BFO. When operated, each push-button is illuminated to show acceptance of the command by the Control Unit. Six interlocked buttons are dedicated to operating modes while a further six are provided for the selection of a symmetrical filter in conjunction with the AM and CW mode switches. The number of filters fitted is limited to three for certain combinations of facilities, in which case the three unwanted push-buttons are blanked off.
The SCORE data used for the interchange of information between a receiver and its control unit is carried on three data highways. One is for forward control, one for a synchronizing clock and the other for revertive check information from the controlled receiver. Audio signals to a monitoring loudspeaker on the MA 1072 are carried on a separate 600 ohm line.
Serial control data can also be derived from a digital computer system by linking the MA 1072 to a keyboard and visual display unit (VDU). Control commands can be selected on the keyboard or be programmed into the main data processor. In this case the control unit push-buttons are illuminated to show the function selected, a particularly useful feature for multi-address and similar functions.
A 7-digit LED display provides a read-out of frequency setting to within 10 Hz. Also included in the display panel are indicators to show correct functioning of the receiver: a 'Fault' lamp is illuminated whenever a receiver fault condition or control system failure is detected; 'AFC Lock' is illuminated when the optional AFC facility is in lock; 'RF Mute' indicates that the receiver RF circuits are muted; and '+20dB' shows that an attenuator has been automatically switched-in due to the antenna input signal exceeding 300 mV.
An additional feature on the front panel enables pre-selected frequencies to be entered from a Frequency Entry Unit Type MA 1083 through a five-way connector. A battery-operated memory circuit is incorporated to store control settings and frequency information during AC supply failure or transit when the control unit is disconnected from its receiver.
The RA1784/MA 1072 combination is fully compatible with the VHF/UHF receivers in the RS 2290 series.



RA 1784 showing ease of accessibility, the boards may be raised into position shown for test and maintenance purposes.



RA 1784 Front Panel.

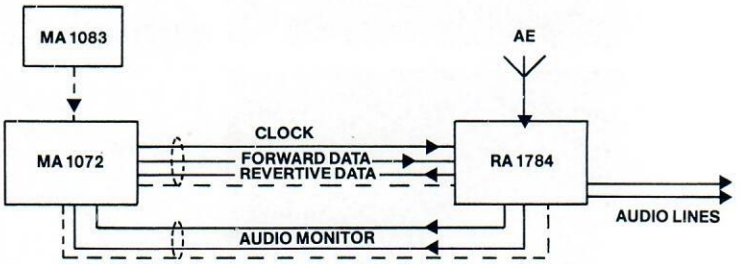
RA 1784 Rear Panel.

MA 1072 Front Panel

MA 1072 Rear Panel.

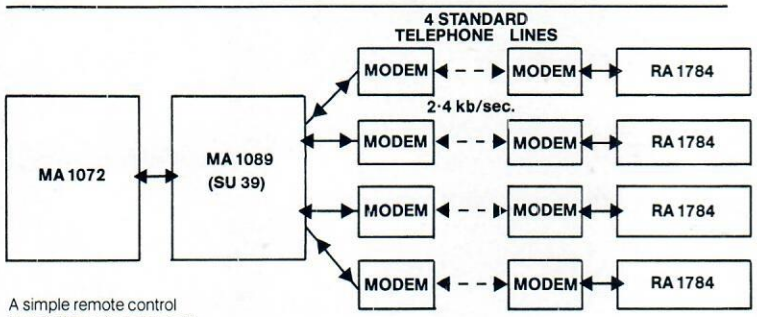
Applications

The application of SCORE to the RA 1784 opens a wide range of possible uses for this high performance communications receiver: from a comparatively simple extended control system to a fully-remote computer-controlled complex involving multiple receiver installations. A number of ancillary units have been designed to complement the basic MA 1072/RA 1784 combination, including the MA 1083 Frequency Entry Unit, MA 1089 Receiver Address Unit, MA 1078 Address Decoding Unit and MA 1082 Multi-address Selection Unit. Further details on these and other SCORE–compatible units are given in separate publications available on request.



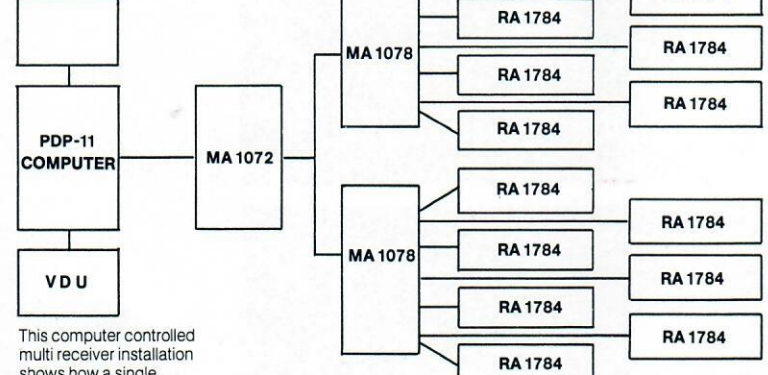
For 'in-house' extended control installations the MA 1072 and RA 1784 may be linked directly through a suitable cable up to 100 metres in length.

Fig 1



A simple remote control installation using standard data modems for the transmission of SCORE data over unconditioned telephone lines.

Fig 2



This computer controlled multi receiver installation shows how a single operator may control 14 receivers and includes storage for 100 channels and provision for auto search/scan.

Fig 3

Technical Specification RA 1784

The performance as stated in this specification is applicable to the wideband condition only. If the optional half octave filter assembly is fitted an additional 20dB of protection is given half an octave removed from the appropriate band edge over the 1-30 MHz range.

Frequency Range
15 kHz-30 MHz.

Modes of Reception
A1, A2, A2H, A2J, A3, A3A, A3B, A3J and A3H depending upon the options fitted.
Options available:
(a) USB and/or LSB
(b) ISB
(c) AFC
(d) Half Octave Filters.

Tuning
Continuously tunable synthesizer in 10 Hz, steps over the entire band.

Frequency Stability
(a) The following optional alternative frequency standards may be fitted:
(i) Frequency Standard Type 9400
Temperature stability: ± 1 in 10^8/°C
Long term stability: ± 5 in 10^9 per day or ± 1.5 in 10^7 over a 30 day period.
(ii) Frequency Standard Type 9420
Temperature stability: ± 6 in 10^{10}/°C
Long term stability: ± 5 in 10^{10} per day or ± 1.5 in 10^8 over a 30 day period.
(b) Provision is made for an external standard of 1 MHz at a level not less than 0 dBm into 50 ohms.

Antenna Input
(a) Wideband 50 ohms to 75 ohms nominal (BNC connector).
(b) Half octave filters are available as an option. These take the form of ten automatically selected bandpass filters covering the frequency range 1 MHz to 30 MHz in which each filter provides an additional 20 dB attenuation half an octave away from the appropriate band edge. A low pass filter is used below 1 MHz.
(c) Receiver muting is provided to protect the receiver from local emissions on the tuned frequency. The operation of the muting circuits permits 'break-in' or 'listen through' operation when keying at a rate of up to 20 bauds.
(d) The receiver will withstand without damage RF input signals of 30V (EMF) continuously. A fuse and spark gap is provided for protection against higher voltages.
(e) Re-radiation with the antenna input terminated in 50 ohms is less than 10 microvolts.

Sensitivity
(a) CW and SSB (A1, A2H, A3A, A3H, A3J).
In a 3 kHz bandwidth the signal-to-noise ratio is better than:
1 MHz–30 MHz, 15 dB with 1 μV (EMF) input.
50 kHz–1 MHz, 15dB with 3 μV (EMF) input.
15 kHz–50 kHz, 15 dB with 10 μV (EMF) input.

(b) DSB (A2, A3)
In a 3 kHz bandwidth the signal-to-noise ratio is better than:
1 MHz–30 MHz, 15 dB with 1.5 μV (EMF) input 70% modulated.
50 kHz–1 MHz, 15 dB with 5 μV (EMF) input 70% modulated
15 kHz–50 kHz, 15 dB with 15 μV (EMF) input 70% modulated.
If half octave filters are fitted the signal-to-noise ratios may be reduced by up to 2 dB from the above figures.

IF Selectivity
(a) SSB/ISB (A3A, A3B, A3J)
Passband at −6 dB: 250 Hz to 3000 Hz
Passband at 60 dB: −400 Hz and +4100 Hz
or
Passband at −6 dB: 250 Hz to 6000 Hz
Passband at −60 dB: −300 Hz and +8000 Hz
(b) CW/MCW/AM (A1, A2, A3, A2H, A3H)
Standard receivers: In addition to the mode-selected SSB/ISB filters, up to four optional IF filters may be fitted although certain combinations of facilities will permit only three filters to be fitted.
IF filters of the following nominal passbands are available: 300 Hz, 1 kHz, 3 kHz, 6 kHz, 8 kHz, 13 kHz.

Cross Modulation
With a wanted signal greater than 300 μV EMF in a 3 kHz bandwidth, an unwanted signal, 30% modulated, removed not less than 20 kHz, will be greater than 300mV EMF, to produce an output 20 dB below the output produced by the wanted signal.

Reciprocal Mixing
With a wanted signal of less than 100 μV EMF, in a 3 kHz bandwidth, an unwanted signal more than 20 kHz removed will be greater than 75dB above the wanted signal level to give a noise level 20 dB below the output produced by the wanted signal.

Blocking
With a wanted signal of 1 mV EMF, an unwanted signal more than 20 kHz removed must be greater than 1V to reduce the output by 3 dB.

Intermodulation Products
(a) Out of Band:
With two 30 mV EMF signals separated and removed from the wanted signal by not less than 20 kHz the third order intermodulation products are not less than 90 dB below either of the interfering signals.
(b) In Band:
Two in band signals of 100 mV EMF will produce third-order intermodulation products of not greater than −45 dB at the IF output.

BFO Range
Continuously variable synthesizer in 10 Hz steps over the range ±4 kHz.

IF Output (AGC on)
100 kHz presettable up to 200 mV (EMF) into 50 ohms.

Audio Characteristics
(a) Output Levels:
(i) Line outputs, 1 mW nominal into 600 ohms balanced, adjustable by preset level control on front panel from −25 dBm to +10 dBm.
(ii) Phone outputs unbalanced 10 mW nominal into 600 ohms.
(iii) Connection for external speaker 1 watt into 8 ohms.
(b) AF Response:
(i) Line outputs. Within 1 dB from 100 Hz to 6 kHz relative to the level of a standard 1 kHz tone.
(ii) The overall AF response will be dependent upon the IF bandwidth selected.
(c) AF Distortion:
(i) Line outputs. Not greater than 1% at specified output of 1 mW nominal.
(ii) Phone outputs. Not greater than 5% at specified output of 10 mW nominal.

Cross Talk (A3B)
With a wanted signal at a level of 1 mV and the AF output adjusted to 1 mW, the cross talk from an equal signal in the opposite sideband, at greater than 400 Hz from the carrier, is not greater than −50 dB relative to 1 mW.

Spurious Responses
(a) External:
External signals 20 kHz removed from the wanted signal, must be at least 80 dB above the level of the wanted signal to produce an equivalent output.
(b) Internal:
The sensitivity figures in the CW/SSB mode are not reduced by more than 3 dB as a result of any internally generated spurious signal.

AGC
(a) Range:
An increase in input of 110 dB above 1.5 microvolts EMF will produce an output change of less than 4 dB.
(b) Remote selection of AGC 'off', 'short' and 'long' time constants.

AFC (A3A, A3B)
(a) AFC is available as an optional internal facility and is provided with a front panel switch for switching AFC in or out of operation.
(b) Capture range: ±50 Hz.
(c) Follow range: ±500 Hz or beyond.
(d) Residual error: 2 Hz maximum.
(e) Memory: In the event of carrier failure or worsening of the carrier to noise/modulation level of 10 dB no retuning is necessary for fades of up to 1 minute.

Serial Data
The binary control system complies with CCITT V28 and the relevant parts of V24. Synchronous 48 bit frames are used.

Metering
A meter is provided on the front panel to indicate RF level, AF level to line, AFC tune and selected performance or supply test levels.

Power Supply
100–125V or 200–250V AC, ±10%, 45–65 Hz.

Power Consumption
Approximately 60 VA (basic receiver).
Approximately 90 VA (with options).

Environmental Conditions
The equipment is designed to meet certain of the requirements of the British Defence Specification DEF 133, L2, for ambient temperature range of:

Operating Temperature	−10°C to +55°C
Storage Temperature	−40°C to +70°C
Relative Humidity	95% at 40°C.

Dimensions
Height: 178 mm (7 in).
Width: 483 mm (19 in).
Depth: 464 mm (18.25 in).

Weight
25 kg (55 lb).

Technical Specification MA 1072

Tuning
Single knob shaft encoder giving three tuning rates; fast, medium, slow. Selected by push button. These tune the receiver in 1 kHz, 20 Hz or 10 Hz steps respectively.

Mode Selection
Six interlocking push button switches illuminated when operated.

Bandwidth Selection
Six interlocking push button switches illuminated when operated.

BFO Control
Single knob control of shaft encoder in 10 Hz increments.

BFO Range
Push button selection of predetermined offset within the range ±4 kHz.

BFO Calibration
Push button selection for zero calibration.

Audio Monitoring
Loudspeaker and phones jack with common AF gain control.

Audio Input
Impedance: 600 ohms.
Level: +10 dBm to −30 dBm.

Phones Output
10 mW into 600 ohms.

Loudspeaker Output
1 watt into 8 ohms.

Distortion (phones and loudspeaker)
Less than 5%, 300 Hz to 3 kHz.

Automatic Gain Control (AGC)
Long/Short time constant, push button selected. Incremental gain control used as sensitivity control or as manual IF gain control by internal linking.

Control Levels
All clock and data connections compatible with CCITT Recommendation V28 and the relevant clauses of V24.

Data Transfer Rates
(a) Internal Clock: 19.2 k bauds +4%–10%.
(b) External Clock: from 100 bauds to 20 k bauds.

Line Characteristics
Loop impedance: 1 k ohm max.
Line capacitance: 2500pF max.

Power Supply
100–125V or 200–250V, AC, 45-400Hz.

Power Consumption
50VA approximately.

Environmental Conditions
As for the receiver RA 1784.

Dimensions
Height: 178 mm (7 in).
Width: 483 mm (19 in).
Depth: 300 mm (11.75 in).

Weight
14 kg (31 lb).

Accessories

AA 650/A
Headset, 600 ohms, with ventilated ear cushions, lead and plug. Headsets are also available with standard ear cushions and anti-perspiration covers.

DA 77060
Bench Mounting Cabinet for RA 1784.

DA 77070
Bench Mounting Cabinet for MA 1072.

Optional External Modules/Units

MM 530
Bandpass filter 2-30 MHz, for use in receiver antenna systems.

MM 532/1 and MM 532/2
Telephone Diversity Switching Units, for use in SSB and ISB operation respectively. For use in speech diversity systems.

SCORE remote control system units as required.

Note:
All accessories and optional facilities and modules/units to be specified at time of order.

Racal reserve the right to vary in detail from the description and specification in this publication.

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